ART. V.—1. *Elements of Natural Philosophy; being an Experimental Introduction to the Study of the Physical Sciences.* By GOLDING BIRD, A.M., F.R.S. The Third Edition, revised and enlarged. London: John Churchill. 1848.

2. *Elements of Physics.* By C. F. PESCHEL, Principal of the Royal Military College at Dresden, &c. Translated from the German, with Notes. By E. WEST. London: Longmans. 1845-6. 3 vols.

3. *Lehrbuch der Physik und Meteorologie.* Von DR. JOH. MÜLLER. Als dritte umgearbeitete und vermehrte Auflage der Bearbeitung von Pouillet's Lehrbuch der Physik. In zwei Bänden. Mit gegen 1200 in den Text eingedruckten Holzschnitten. Braunschweig: Friedrich Vieweg und Sohn. 1848.

4. *Grundriss der Physik und Meteorologie.* Von DR. JOH. MÜLLER, Professor der Physik und Technologie an der Universität zu Freiburg im Breisgau. Zweite vermehrte und verbesserte Auflage. Braunschweig: Friedrich Vieweg und Sohn. 1850.

5. *Principles of Physics and Meteorology.* By J. MÜLLER. First American Edition, revised and illustrated; with 338 Engravings on Wood, and two Colored Plates. Philadelphia: Lea and Blanchard. 1848. 8vo. pp. 635.

FEW persons, we presume, at the present day and in this country at least, are disposed to deny that scientific culture and, as one of its elements, instruction in physical science, should hold a place, and not an inconsiderable one, in every system of education. It would not, perhaps, be wise to insist that the amount and the kind of instruction in physical science should be the same for all minds, whatever their innate characteristics, and however different their destination. We believe, nevertheless, that, at an early age and until the mind begins to act for itself, less modification of the general scheme to suit individual peculiarities is demanded than many seem to suppose. And this we say, not because we desire to thwart genius, or reduce to a dead level the manifold inequalities of intellectual gifts, but because we believe that

the symmetry of the mind gives it its best strength, and that an unbalanced mind will make shipwreck of its treasures, however richly it be freighted.

We know there are those who, after they have divided the whole period allotted to an academical education equally between the many various branches which are promised to be taught, exclaim with earnestness, how insignificantly small, how utterly inadequate, is this crumb of time which falls to the lot of any science for its useful acquisition, or even for a proper appreciation of it! How much better would it be, that the student should devote himself exclusively and passionately to one, or, at most, to a very few, of these branches, rather than, in the vain hope of not losing one, to fail in the whole! They forget that the whole period of education at school or in college is not equally divided in this way; that many branches, as, for example, the ancient languages and the mathematics, are begun early and studied perseveringly, and are discontinued at a late day; and that these, if not exhausted, as indeed they cannot be, by the undivided absorption of a life in their pursuit, are at least mastered. Of other branches of knowledge, such as the chemical and physical sciences, philosophy, ethics, history, and the rest, all which are crowded into a very narrow period by the preference given to those first mentioned, the remark is strictly true, that this time, so short in itself, is almost annihilated by the divisions and subdivisions which are made of it. But our own experience and observation persuade us, that this time, broken into so many fragments, is not frittered away; that the student obtains a general view of the boundaries of human knowledge; makes the first rapid, preliminary survey; clears away some of the rubbish which intercepts his steps; wipes out from his eyes a part of the mist which dims his vision, and, in science at any rate, breaks the ground. However small a thing this may be, when contrasted with the lifelong acquirements of giants in their favorite walks of science or literature, it is still much when compared with blank ignorance. For, next to the acquisition of any branch of knowledge, the best thing and most to be desired is, to know that it exists, in what books it may be studied, how far its horizon stretches, and what place it occupies in the wide realm of related sciences. If the time

for all these studies is so small, instead of consenting so readily to elect a few and drop the rest, why not strive with energy to increase the period of education? Why not enlarge the course of college education by one or two years, and that of school education in the same proportion; and above all, why consider that the whole of education is accomplished when either is gone over?

To achieve such a radical reform as this, which would remedy some of the difficulties experienced by those who teach, it is necessary that a vigorous effort be made to withstand the strongest tendencies of the young, especially in this age and country, — an impatience of long and unfaltering toil for a postponed advantage; an intolerance of control; an eagerness to put on the harness of real life, and a boasting when it is put on, as though it were taken off, after the strife was over and the victory won. Strange is it, that now, when the boundaries of human knowledge are so much enlarged, circle outspreading and surrounding circle, like the ripples on the sea, — when science is constructed and extracted from the passing phenomena of nature, when it comes to us in such solemn accents from the bosom of the earth, when it speaks to us out of the heavens so beautifully and so accurately, — no more time should be thought necessary to ponder upon all these things than was given to the education of the young centuries ago, when books were so rare, and all that was then known of some which are now the richest sciences could be told in a single breath.

In the intellectual as in the material world, there is one kind of strength (the best strength of the mind) which time only can bestow. This strength comes not from brilliancy of parts or from indefatigable exertion; it is the gift and ornament of age and maturity. How many at the present day have bidden farewell to their places of education before that strength has come into their minds? And yet, that strength of mind is indispensable for the comprehension of abstract science, and for the successful study of other very important branches taught in our schools and colleges. Hence the complete failure of many, even brilliant in all their other studies, when they advance prematurely upon these unfamiliar fields. Hence the regret which, not seldom, falls from the lips of those who have left their days of pupil-

age far behind them, that their minds were not opened then to the truth and beauty and attractiveness of studies with which their full-grown intellects are in love, but which then were accounted dry, because they were not, and could not be, understood by them.

How any considerable extension of the period of education is to be effected, it is not easy to discern. When we see, every year, young men anticipating the customary termination of time studies, curtailing the period, short as it appears for the duties which belong to it, and hurrying to take leave of the retreats of the academy, that they may get the start by a few weeks or months of their companions; when we see them reconnoitring in their professional studies, beginning to teach others, embarking in trade, or putting out their hands for the gold of California, before they have yet earned or received their diplomas, how can we expect to restrain the impatience of even the most scholastic for an additional service of two years in the schools? How can we expect that the gentle persuasions of sound education, good learning, and profound science will be heard above the din of the world without, and the fever and passion of the world within? Difficult as it may be to accomplish a reform so much to be desired, who that takes pride in the character of our places of education, in the originality of our literature, in the accuracy and depth of our science, in the success and happiness of our young men, and in the honor of the whole country, is not ready to pray for this reform, to watch for it, and to labor for it?

Every day the struggle is growing more and more intense for the honors of life between those whom our colleges educate and those whom the world educates; between professional men and practical men, as they are called. There can be no doubt that the world educates men thoroughly in what it professes to teach. Colleges must do the same. They need not aim to be less scholastic, or to teach what the world teaches; but they should teach perfectly after their own idea. Otherwise, the world will educate the most useful members of society, and college men will fail of their share in the honors and emoluments of life. What man of science, however much he may glorify his profession, does not consider a thorough practical acquaintance with any art as both more useful and more dignified than a superficial

knowledge of the laws, principles, and theories of science. Patient instruction by the worst system is certainly better than careless instruction by the best system. Already there are springing up in various parts of the country practical schools of science, which profess to teach that which comes nearest to what the world teaches. We wish them all success; we doubt not, that if they are true to their idea, they will render an acceptable service to the cause of education. But let not those who frequent them be deceived. Let them not expect, after a few months of study and experiment, to go forth into the world and displace those whom experience and the arts have been teaching their lessons of science for years. If they are persevering as well as diligent, they will have their reward. But without both diligence and perseverance, they will know but in part the scientific truths which the artisan and the manufacturer have distilled from their daily pursuits.

The inquiry is always a serious and interesting one, in what way any province of human knowledge may be best opened to the mind of the student. The inquiry loses none of its interest or importance when it is made in reference to the more difficult subjects of instruction. In the difficulty, bewilderment, and frequent dismay which they occasion to the young, the physical sciences will take rank of all the other sciences, and perhaps also of all other branches of learning, excepting the pure mathematics. The reason is, that the physical sciences involve the application of mathematics, and sometimes of its most subtile and intricate departments. And who does not know that the application of any knowledge to the problems for which it is suited is harder than to acquire the knowledge; that it is verily the severest test of the question whether this knowledge exists in the mind in clear and distinct outlines. This application implies, not merely acquaintance with a truth, but familiarity with it, in its principle and its details. Moreover, the same rule holds good in mathematical as in moral reasoning. The soundness of our conclusion depends not merely on the exactness of our logic, but also on the correctness of the premises.

Whoever begins the study of physical science without some knowledge of geometry, and the algebraical and infinitesimal analysis, will find himself confronted at every step by

an imperious call for this sort of preparation. The physical student needs the helping hand of mathematics to expound to him the theory of the instruments which he uses; he needs them in his investigations into the physical laws of the universe, and he needs them none the less to express those laws after they have been discovered. If not only the sober planets, but the nomadic comets, tread so precisely in their prescribed orbits as to test the precision of pure geometry; if it be true not only in the heavens, but in all material nature, that God geometrizes in it and through it; if He, not merely by his providence, but by his geometry, rides on the whirlwind and directs the storm; if sounds rush through the air, if the tides ebb and flow, if the waves rise and sink and spread, if the finer essences of heat, light, and electricity radiate, interfere, and flash in harmony with the most profound mathematics; if even the trees, shrubs, and weeds bud and branch and blossom according to mathematical formulas which the Almighty has copied from the grander works of his own creation, — ought not the humblest student of the physical sciences to have a taste of that divine geometry which filled to overflowing the minds of the great seers and prophets of nature? We have no disposition to deny the intrinsic difficulties of the pure and mixed mathematics; we think, nevertheless, that a tendency exists to exaggerate these difficulties, and also to make of too much account what is considered a primitive bias for or against these studies. There is, certainly, this peculiarity in the case. It is not possible to use the language of mathematics without understanding the associated idea; it is not possible on this subject to darken counsel by words without knowledge. The consequence is, that those who do not understand a mathematical problem are themselves the first to know their own deficiency. But is it always so in other things? In other subjects, does not a want of clear conceptions sometimes exist where there is no lack of fluency? It may well be doubted, whether the mental labor which the mathematician expends on his most difficult problems differs either in quality or intensity from that which the statesman, the moralist, or the philosopher, incur when they master the deep questions relating to politics, ethics, or the human mind.

A foundation for physical knowledge being laid in a good mathematical education, another interesting inquiry is sug-

gested as to the best method of imparting instruction in the physical sciences; whether by lessons from a text-book, or by oral lectures, or by the two united. In our opinion, there are few, if any, branches of knowledge which can be taught to advantage exclusively by oral lectures. Certainly, the physical sciences are not of that number. At the same time, perhaps there is no subject in which such lectures are a more valuable auxiliary than in physics. Many of the physical sciences are in a state of rapid development. In some, we hardly know what a day may bring forth. Old lines of research are widened and lengthened, and new ones, intellectual Californias, are struck out and deepened with unexampled rapidity. The text-book, be it ever so complete when it is written, may grow obsolete before it has left the press. Lectures, therefore, are a valuable handmaid to the written and printed page. They are the fit vehicle for new discoveries, for the discussion and elucidation of questionable theories, for historical anecdote, for biographical sketches of the great interpreters of nature, and for experimental illustration. For these and other such purposes, lectures are not only useful; they are indispensable. But to fulfill these purposes, lectures must not be written. They must come from the present studies and reflections of the teacher, and give, as in a daguerreotype, a faithful image of the passing history of science. To this end, if written, they must be rewritten every year; but as this is not to be expected, they must not be written at all. Hence they will be loose and discursive, and require to be corrected in their details by the carefully prepared statements of the text-book. They may illustrate, therefore, the text-book, but they ought not to supersede its use. We would not lose sight of the magical effect which may sometimes be produced upon the young by the living voice of the lecturer. If there be any one whom nature has gifted with the eloquence of science, let him lose no opportunity to charm and instruct by it. For it may be the spirit which maketh alive, while the printed page is the letter which killeth. But let not even such a one deny or disparage the different merit of the select text-book.

Some degree of the embarrassment which the young experience in the study of mathematics originates, we are persuaded, in an organic defect of vision for solids of three

dimensions; a deficiency which has not been supplied by familiarity with the principles of perspective geometry. It is now well understood, that the eye possesses the power, only within very moderate limits, of measuring the distance of an object which it contemplates; and that it is often, on this account, at a loss in assigning the correct position to a line or surface, the several points of which are at unequal distances. When the dimension of a solid measured in a direction parallel to the visual ray is small compared with its distance, the parts of the body turned towards the eye are too nearly at the same distance with the opposite parts, and the visual rays passing from the borders of the body to one eye are too identical in their arrangement with those which enter and paint their picture on the other eye, to furnish any satisfactory data for deciding which of two possible positions the body occupies; so that the mind oscillates unquietly between the two, however intently the eye attempts to fasten one and expel the other from the imagination. This optical delusion is a matter of common experience, and admits of a philosophical explanation. This instability of vision, which sometimes is experienced in looking at a distant solid body, is still more likely to arise when we look at a picture of it in outline, unrelieved by shading. Who can doubt that we have here one source of the confusion worse confounded of the young student of geometry? He draws his diagram upon the black-board, or he gazes upon it on the leaf of his text-book, and as he hopefully advances in his demonstration, his eyes swim, the figure jumps from one position to another, and soon his mind is confused, and he gives up in disgust. We believe that the failure of the young to master solid geometry originates as often in this organic peculiarity of vision, existing to excess, as in any deficiency purely intellectual. We believe that a geometrical eye is quite as indispensable to the success of the mathematician as a geometrical mind. The student who pores over perspective delineations, in order to decipher the construction or position of a new philosophical instrument, or of the mechanical arrangements of a novel experiment, encounters a difficulty similar to that which puzzles the young geometrician. Hence the importance of maps in relief for those who would understand the geological and topographical features of the earth; of model solids for

those who would not be defeated in their geometrical studies; hence the value of at least one glance at the various complicated instruments of research, either in their full working dimensions, or in miniature, for those who would not be wholly cast down in the study of astronomy and the physical sciences. Hence the necessity of furnishing the experimental illustration as nearly as is practicable at the same time that the instruction is given from the text-book; or, at least, of placing before the eye of the pupil the instrument delineated in his book, when he is called upon to study and describe it. It may be thought that too much assistance of this kind relieves the pupil from intellectual exertion, and defrauds him of the energy of mind which constant, strenuous exercise imparts. We, too, admit that there is, in general, a limit to the facilities for learning that should be granted to the young. But, in our opinion, all the relief that can be contrived is only sufficient to carry many a student over difficulties in the pure and mixed mathematics which would otherwise be insurmountable.

There is still another view which we would present of the advantage of instructions from the text-book, illustrated by oral lectures, over the exclusive adoption of either of these methods of teaching. Lectures are an excellent discipline to the teacher. They require him to concentrate his thoughts, to make up his mind on doubtful scientific questions, to inform himself thoroughly in the literature of science, to acquire a skill in manipulation that will qualify him for original investigations, and, finally, to look at the whole subject of physical science less in detail, and more as the harmonious working of a single creative mind. Now, who does not see that a part of these advantages are realized by the student who recites from a text-book? He is not a passive recipient merely. His mind is exercised not only on the subject of his studies, but on the best way of expressing with propriety what he has learned.

In urging, as we have, the preëminence which belongs to instructions from the text-book, we have assumed that these text-books were of the best kind; well arranged, accurate, clear, and frequently remodelled, so as to exhibit the passing phases of science. We may venture a doubt whether the text-books used at our schools and colleges always come fully

up to these high conditions. Many are so ambitious of authorship, that they must write a book at all hazards, however unprofitable it may turn out to themselves or to others. Moreover, a teacher, who begins to experience the imperfections of the best text-book which he can procure on any subject, naturally concludes that his only remedy is to make one for his own use. If he surpass his predecessors in the same field, it is well. If he fall short of the goal which they reached, he has done more harm than good. Let no teacher be too confident that he will escape faults into which others of much higher qualities of mind have fallen; or, if he should, that he will not commit mistakes of his own equally injurious. Let him reflect that he can, by his method of teaching, supply the defects of any text-book; and that, whenever he does so, the pupil is brought into contact with two minds instead of one. As things now go, the few who are best qualified to write find no pecuniary temptation to embark in the unprofitable enterprise. Particular institutions are pledged to the use of particular books. Each college, each sect, each publisher, is interested in his own series of text-books, and labors to increase their circulation. In the eagerness of such a competition, it is not certain that the best will acquire the ascendency. It may sometimes happen, that the one which is sustained by the strongest sect or the largest capital will prevail over another which teaches better science. Moreover, the American publisher prefers a foreign work, which costs nothing, or at most only the expense of a translation, to domestic authorship, however deserving, and however superior to that which is *borrowed* from abroad and never to be returned. We are far from wishing to curtail the literature of science. We do not desire to see all drinking from the same fountain, be it ever so copious and salubrious. We would look at this outward universe, and take care that others look at it also, from many points of view; and supply the deficiencies of one mind by the excellences of others. We would see the standard scientific works in every language translated into our own tongue, and made accessible to the American student. We would not confine any teacher or any institution to the exclusive use of any single series of books, however good. For the sake of the teacher as well as the pupil, we should prefer frequent changes in the text-

books; so that, if no single student or class of students were able to compass all, or more indeed than a single one, a succession of classes might be the depository of the treasures of all; and thus the whole neighborhood, the city, the state, the country, which are fed by this common stream of educated men, partake of a more liberal culture and drink from clearer and deeper fountains.

A good text-book should be comprehensive in its general plan and very exact in its details. It should be written in an accurate and clear style, and, what is equally important, it should be printed in a distinct type. Some of our reprints of foreign scientific works have greatly offended against this last requirement, and deserve severe censure for it. Such books ought not to be placed in the hands of the pupil; for not only do they tend to ruin the eyes, but they oppress the imagination, and cast their own lurid light into the darkness which may hover over the subject itself. Equally contagious is the brightness of the pure white sheet and the clearness of a bold, generous type; by its light even a difficult subject seems transparent. So rapid has been the growth of modern physical science, that no work, however voluminous, could contain the half that might be written. The author who assumes the task of making a text-book is required to use great discretion, and to exercise a happy judgment, in selecting what is most essential, not forgetting to interest while he aims to instruct. The writer cannot confine himself to the naked principles of physical science; for at present these are not numerous. The literature of science does not consist chiefly in the great laws which have been discovered; but in the history of discovery, in the instruments of research which have been contrived, in the facts which suggested, and the experiments which illustrate, general laws. We prefer, as a general rule, the synthetic method, which in point of time travels backward, planting first the great principles and generalizations of any science, building on them as a foundation, and deriving the scattered phenomena of nature as branches from the central trunk. There may be cases in which the analytical method may be called to the assistance of the former method. For, although less easy, it has the advantage of conducting the pupil through a process of thought not unlike that which warmed the

minds of the original discoverers; and thus associates with the principles of science its history and the laws of discovery. Finally, no pains should be spared by the author and teacher to hold before the mind of the student, and to keep there, the unity of nature, and the intimate connection of the physical sciences as they stand out before the mind of the Creator, however disjointed and fragmentary they sometimes appear to the imperfect reason of man.

While the recent scientific literature of France is adorned by the general treatises on physics of Pouillet, Lamé, Peclet, Pinault, Becquerel, and Despretz, the English language can only boast of the works in Natural Philosophy by McGauley, Olmsted, and Bird. Of course, we are not speaking of school-books, but of such works as might be appropriately used by advanced students in college. General physics, as treated by French writers, exclude the pure science of mechanics, as well as algebra and geometry, and only admit their application to physical problems. In this view of the subject, physical astronomy is a part of physics; but on account of its magnitude, it is not discussed in works on general physics, but either in a distinct work, or in connection with mechanics; of whose fundamental principles it often furnishes the most convenient and splendid illustrations. The English treatises enumerated above are constructed upon the old English model. Natural Philosophy, as limited by usage in this country and Great Britain, comprehends a part of what the French writers style *physics*, and, in addition, the science of mechanics. These books contain, therefore, the doctrine of forces, in its twofold relation to statics and dynamics, as well as the application of the general doctrine to the physical forces. To make room for mechanics, a part of what truly relates to physics is dropped out of English works on Natural Philosophy, and is adopted by the chemists in their books. In our opinion, the English division of the sciences is less philosophical than the French.

We do not expect that a work like that of Dr. Bird, condensed into a single octavo volume, should compete with the more comprehensive treatises in the French and German languages, which are expanded over two or three volumes. We may, notwithstanding, express our astonishment that the demands of scientific education in Great Britain and in this

country are no higher than what can easily be satisfied with such compendious and elementary productions. We are aware that the works on physics in foreign languages, especially in French, are extensively read by scientific men in this country, and, we presume, in Great Britain also. Still it would appear that the demand for these or similar treatises is too small to provoke original works, or even translations of the foreign ones, except in one or two instances.

This deficiency in one department of English scientific literature is partly explained by the fact, that the talent (and it certainly has been of a high order) which might have been exercised in this way has been preoccupied in writing monographs in science for such series of publications as the Cabinet Cyclopædia, the Library of Useful Knowledge, the Penny Magazine, and the Encyclopædia Metropolitana. Of some of the papers contained in these valuable depositories of science, too much cannot be said in praise; they adorn the sciences which they are written to illustrate. The article on Light, in the Encyclopædia Metropolitana, by Sir J. F. W. Herschel, is unsurpassed by any thing which has been written on the general subject in any language; and, if published separately in an accessible form, as it is in Quetelet's French translation of the original, it would be very useful to advanced students in that subject as a text-book. The same work contains a paper on Sound, written also by Herschel, in which the remarkable labors of Chladni, condensed into his *Traité d'Acoustique*, are introduced to the English reader, and the more recent labors of Savart and Wheatstone in the same field are infused into the popular science. The American reprint of this paper, in an abridged form, with some modifications in the statements and explanations, has supplied a convenient text-book, better adapted to the purposes of instruction than Higgins's Philosophy of Sound. The article on Physical Astronomy in the Encyclopædia Metropolitana, by Herschel, and another, on the Figure of the Earth, by Airy, are not designed for elementary use. The articles on Electricity, Magnetism, and Electro-Magnetism, by Barlow, are less satisfactory than those on the same subjects by Roget, in the Library of Useful Knowledge. The latter publication contains also articles on the other branches of physics as well as astronomy; but most of them are too

popular to be recommended to our academies or colleges. In the Cabinet Cyclopædia, astronomy, mechanics, physics, and chemistry are treated in a liberal number of volumes. These treatises, in their present form, are, perhaps, better adapted to academical use than any thing else which can be found in the scientific literature of Great Britain. Still, they are far from being unexceptionable in their plan or execution. In general, they are of too popular a character, and moreover, being prepared by different authors, they want that unity of thought which should run through a general treatise on physics, and which is necessary to imprint upon the mind as well as the heart of the student the great fact, that, though man studies the universe in detached views, God created it and moves it as one grand whole.

Herschel's Astronomy, which makes one volume of this Cabinet, did not certainly satisfy the high expectations excited by his elegant discourse on the study of natural philosophy, which had charmed the world a few years before, from the same Cyclopædia. The literary style of Herschel, though often beautiful and eloquent, is highly involved, and forcibly reminds one of the German origin of the writer. This ornate, elaborate, and dignified diction, which appeared graceful and impressive in his stately discourse just mentioned, is singularly out of place in the treatise on astronomy, where the multiplicity of words, the length of the sentences, and the rhetorical flourishes, perplex the student and mislead him from the subject. The chief difficulty in the study of astronomy is to form a graphic conception in the mind of the physical fact. We doubt whether this conception is so strongly suggested by highly ornamental language, with which wholly different ideas are usually associated, as by the simple lines and the brief and severe definitions of geometry. Nevertheless, we have always regarded the chapter on perturbations as a triumphant effort to render into common language, and illustrate by familiar analogies, difficult points in the celestial mechanism, which, to be altogether understood, require the highest order of mathematical taste and attainment. This part of the book has been still more carefully labored in the recent edition, which has appeared under the new title of the Outlines of Astronomy; and, if studied in connection with Laplace's *Système du Monde* and Airy's tract on Gravi-

tation, written for the Penny Cyclopædia, but previously published in a small volume for the use of students in the elder Cambridge University, it will supply an intelligible commentary on the most embarrassing department of astronomy, such as is not to be found in any other language, and open an easy way to a general comprehension of dynamical questions, which a discouraged student would otherwise approach with dismay and abandon in despair.

The volumes of the Cabinet Cyclopædia on Electricity and Magnetism are partly historical, and partly didactic. A mutual infusion of one element into the other would be more suitable for a text-book than this bold demarcation. The first volume, by Lardner, is well arranged and well written; the second volume, begun by Lardner and finished by Walker, is a compost, in which some of the materials are good, but the whole is poorly digested. For those who desire to pursue experimentally the subject of electro-dynamics, Davis's Manual of Magnetism will be preferred to any other elementary work. Of the treatise on Optics in the Cabinet Cyclopædia, we can speak from a long experience. Justly distinguished as its author, Sir David Brewster, stands in this department of physical science, his strong bias in favor of the Newtonian or corpuscular theory of light disqualified him for writing a useful text-book on the subject. The obscurity which rests on all those portions which relate to double refraction and polarization originates in the false views of its illustrious author in regard to the mechanical character of luminous radiations. A large part of physical optics is a sealed book to most students. Much of the confusion is created by the improper terms which are used in describing the phenomena; terms which were selected at a time when the mechanical interpretation of the phenomena was erroneous. Who will not hail the appearance of a book in which the geometrical, as well as physical, laws of optics are explained on the undulatory hypothesis? Of course, we do not expect that elementary works should dip into the higher analysis by which the mysteries of optics are investigated and charmed out from their amazing labyrinths. We do not despair, however, of seeing a popular exposition of the doctrine of undulations, which shall bring the subject under the comprehension of all who are conversant with the elements of geometry, algebra,

and mechanics; and we have faith that some will be able to understand the intricate facts of physical optics from this point of view, who stumble over the explanations of Brewster and Biot, or of others who aspire to compound the two rival theories. English scientific literature, without any foreign loan, abounds in materials for such a work, graduated to any degree of abstruseness or simplicity. The admirable papers of Hamilton, M'Cullagh, and others, the celebrated tracts of Airy, all on the mathematical theory of light, the lectures and remarks by Lloyd and Powell on the wave theory of light, the lectures of Pereira on polarized light, the elementary optics of Brewster, Potter, and Wood, and, finally, the highly finished monograph of Herschel, to which we have already referred, contain the golden threads, already refined and elaborated, out of which a more beautiful and perfect fabric might be constructed. A work very recently finished in Paris by the Abbé Moigno, entitled, *Répertoire d'Optique Moderne*, gives a complete analysis of modern labors in relation to the phenomena of light, and, although not itself after the model of a treatise, would be very convenient and suggestive in the preparation of such a book.

We have mentioned the tenacity with which Brewster clung to the corpuscular theory of light, as an obstacle in the way when he wrote his treatise on optics. But the book is open to farther criticism. It lacks salient points, which the pupil may quickly discern and fix in his own mind. Sometimes, it dissipates in too great detail, and does not always hold the balance with a firm and equal hand between those discoveries and inventions to which time has given its sanction, and novelties which have only a passing, momentary interest. Great caution is necessary not to overrate the recent progress of science, as compared with its former advancement; since even the steps of a giant, if measured from a distance, would appear no larger than those of a dwarf or an insect. Without the precaution at which we have hinted, the time arrives which reveals palpably the injustice and partiality of an author, and the punishment, which is not long delayed, awaits him, that his book becomes prematurely obsolete. We ought not to leave this subject without remarking, that the American teacher has within his reach two other elementary treatises on optics, one by Professor Bartlett, of West Point, and the

other by Professor Jackson, of Union College, each of which is well adapted to the purpose for which it was intended.

Other works have appeared in England, within a few years, which are related more or less closely to physical science. Among these we will particularize Daniell's Chemical Philosophy, Carpenter's Mechanical Philosophy, and Moseley's Illustrations of Mechanics. Illustrations of other branches of Natural Philosophy, by the professors of King's College, have been long promised, but have not yet come.

It will appear from the rapid and partial glance we have cast at the scientific literature of Great Britain and this country, that there are in the English language the materials for a satisfactory text-book on general physics, and that very good works on special physical subjects and for particular uses already exist. Is it not time that the other want should be felt, or if felt, should be supplied? Is it not time that some one of the eminent explorers of physical science in Great Britain or this country, should do for the men of this generation what Young, Robinson, and Leslie did for the last, and produce a work on general physics which shall rival those of Peschel, Pouillet, Lamé, Peclet, Müller, or Regnault?

Let us see to what extent the want in question really exists. We know of no work, originally written in English, which embodies recent discoveries in physical science, and truly represents its present state, so well as Bird's Elements of Natural Philosophy. The first edition of this book was published at London in 1839. Its success is indicated by the fact that it was soon out of print, and a second edition was demanded in 1843, and a third in 1847. It is certainly a reproach to the physical science of those nations which speak the English language, to be indebted for the only prompt effort to diffuse its latest teachings to the necessities of a professional lecturer in Guy's Hospital, who, because he could not find in his language any work fit to be recommended to his pupils, set himself to work to make one. In the preface to the first edition, Dr. Bird gives the following explanation of his attempt at authorship.

"The best apology that can be offered for presenting this volume to public notice, will be found in the reason which suggested its compilation, namely, — the absence of any system of physics sufficiently extended to include all those subjects with which men

of education, especially members of a liberal and important profession like that of medicine, ought, and are required to be familiar with, and at the same time not too diffuse to disgust or weary the student."

Dr. Bird has given to his subject its widest signification. The general physical and mechanical properties of bodies, the laws of equilibrium and motion, when applied to the three great divisions of matter into solid, liquid, and gaseous, — the mechanical powers, — acoustics, magnetism, electricity, (mechanical, chemical, animal, magneto- and thermo-,) the geometrical and physical properties of light, polarized and unpolarized, optical instruments, thermotics, including the statical and dynamical laws of heat as applied to combined and radiant caloric, and photography, — all these subjects are fitly introduced, but they are treated with extreme brevity. Meanwhile the author has had his eyes wide open on the current movements in physical science, and the later editions have reaped the fruits of his enlarged studies and of the scientific activity of the age. We are gratified by notices, however short, of the researches of Melloni and Forbes, on radiant heat; of Herschel, Moser, Hunt, and Brookes, on photography and kindred subjects; of Dr. Davy, Faraday, and Matteucci, on animal electricity; of Breschet, Becquerel, and Crosse, on atmospheric electricity; of Grove, Smee, Bunsen, Daniell, Ohm, and Faraday, on voltaic electricity. We are astonished to find that there is room in so small a book for even the bare recital of so many subjects. Where every thing is treated succinctly, great judgment and much time are needed in making a selection and winnowing the wheat from the chaff. Dr. Bird has no need to plead the peculiarity of his position as a shield against criticism, so long as his book continues to be the best epitome in the English language of this wide range of physical subjects. He excels in those departments of chemistry and physics which come into close contact with the medical profession. The chapters on electricity, especially on physiologic electricity, are of this description. Voltaic electricity is presented in a form surpassed only by the admirable treatment it has received in Daniell's Introduction to Chemical Philosophy.

But Dr. Bird touches with a timid and unsteady hand other subjects, with which his favorite studies have not made him

familiar. His elements are particularly defective in those parts which involve geometrical conceptions, or require an accurate mathematical analysis to be so entirely understood that they may afterwards be correctly presented in other language. This criticism bears with force upon those parts of the book which relate to optics. For example, in paragraph 600, Dr. Bird, in attempting to explain the magnifying power of convex lenses, and the diminishing power of concave lenses, confounds the *border rays*, coming from the same part of an object as the central rays, with those which come from the *borders* of the *object*. Again, in the second part of the next paragraph, we read, "thus, it is evident, that in viewing an object through a lens, the longer the focal distance, the lesser apparent angle is it seen under, and *cæteris paribus*, the smaller it appears; whilst the shorter the focal length, the greater the apparent visual angle of the object, and the larger it appears." This is the reverse of what is true in reference to concave lenses.

We may take this opportunity of saying, that the simple rule ordinarily given for finding the magnifying power of a microscopic lens, — namely, to divide the distance of distinct vision by the principal focus of the lens, — will lead to confusion if it is applied to lenses in general. For, if the focal length of the lens were greater than the distance of distinct vision, the quotient of the rule would be less than unity, and the lens would diminish instead of magnifying, which is never true of any convex lens held close to the eye. The true principle may be stated in a few words. The rays which proceed from an object to the eye must fall within certain limits of divergency, in order that the object may be seen distinctly by that eye. This divergency decides the distance at which the object must be placed to be clearly seen; and this distance, determining, as it does, the apparent visual angle, fixes the visible size of the object. Any contrivance by which the distance of distinct vision is increased, is for the purpose of diminishing the visible size of the object; and any other contrivance by which this distance is diminished, serves to increase the visible size of the object. Concave lenses always make the emerging rays more diverging than the incident rays. Hence the object must be placed farther off, that the diminished divergency of the original rays may compensate for the

diverging action of the glass. Such a lens always diminishes. Convex lenses always make the emergent rays less diverging than the incident rays. Hence the object must be brought nearer, that the increased divergency of the original rays may check the converging action of the glass. Such a lens always magnifies.

In paragraph 603, Dr. Bird says: —

"On referring to the diagram of the course of rays refracted by a convex lens, it will be seen that the rays passing nearest the axis of the lens will be refracted to a focus at a greater distance from the glass than those which pass nearer the circumference. On holding a screen of ground glass near the focus of the central rays, a picture of an object on the other side will be seen very vivid in its centre, but less distinctly defined at its edges; on gradually withdrawing the screen, the marginal portion of the picture will become vivid as the centre loses its distinctness. Hence it is obvious, that no object can be seen with perfect distinctness in every part, through a convex lens, at the same moment, in consequence of this *spherical aberration*, as it is termed."

Here the author makes no distinction between the aberration of oblique pencils, and the aberration of the oblique rays of the central pencil. Besides, neither the one nor the other of these two aberrations appears by referring to the diagram indicated by the author.

In paragraph 655, we find this statement:

"With regard to the comparative rapidity of propagation of the two sets of undulations, into which light incident on a doubly refracting crystal is resolved, Huyghens has demonstrated that the difference between the squares of the rapidity is equal to unity divided by the square of the sine of the angle formed by the ray with the axis. In calcareous spar, the ordinary ray therefore moves with a greater velocity than the extraordinary one."

Now, but a slight acquaintance with mathematics is wanted to perceive that, when the internal ray is parallel to the axis, and the angle spoken of in the rule is equal to zero, unity divided by the square of the sine of this angle becomes infinite, and the difference between the velocities of the two rays infinite also; whereas, in fact, the two rays, in the case supposed, travel in the same direction and with the same velocity.

We have another instance of Dr. Bird's inaccurate analysis in paragraph 689. "On this account," he says, "no colors

were seen when the selenite was viewed without the analyzing plate or calc-spar, as *both* rays then reached the eye together, and produced a white image." The true reason why the colors in question are not seen without the analyzer is, that they are *produced* by the analyzer. In paragraph 27, we read: "The utmost elevation attained by the fluid in this arrangement is one half of that which would have taken place in tubes having their diameters equal to the distance between the plates; and being always inversely as this distance." We do not understand the meaning of this statement. The law is this: the elevation attained by the fluid in this arrangement at any distance from the angle of the plates is equal to one half of that which would have taken place in a tube whose diameter was equal to the interval between the plates at that point.

In paragraph 71, the student is thus instructed: "A cannon-ball, of three pounds' weight, possessing a velocity of three hundred feet in a second, will possess as much momentum, and strike any opposing substance with as much force, as one of thirty pounds moving at the rate of thirty feet per second, for $300 \times 3 = 30 \times 30$." The truth of this statement depends on the definition that is given of force, and we have no desire to stir the not yet extinguished embers of the protracted controversy on this subject. We will only say, that if the force of the ball is measured by the depth to which it can penetrate into a timber or into a column of men, the first ball has ten times the force of the second.

In paragraph 130, it is said, "when the pulleys are connected each to a separate string, the ends of the latter being attached, not to a beam, as in the last case, but to the resistance to be overcome, some mechanical loss is sustained, and equilibrium is obtained when $P : R : : 1 : (2^n - 1)$; 2^n being the power of two, whose index is the number of movable pulleys." This rule makes this arrangement only about one half as efficient as it really is.

Speaking of the magnetic needle, in paragraph 265, our author says: "The greatest variations ever observed were by the Chevalier de Langle, between Greenland and Labrador, amounting to 45° W., and by Captain Cook, in 60° S. latitude and 92° 35′ longitude, when the variation amounted to 43° 6′ east of the geographic meridian." Now, Captain

Ross, on the 31st of August, 1818, in latitude 74° N., and longitude 80½° W., observed a variation of 114°. Capt. J. C. Ross, in his cruise of 1840 – 1, observed a variation in the southern hemisphere of 114° 21′; and Lieut. Moore, in 1845, another amounting to 52° 17′.

In paragraph 592, Dr. Bird has omitted the value of the radius of the sphere, without which the statement has no meaning. He says, in paragraph 695, "An alteration in their size is also of constant occurrence, the rings being largest in the most refrangible, or violet, light, and smallest in red light." It is quite obvious that the very contrary is true. The author may have copied the mistake from his authorities, as we notice it frequently occurring in other books by some strange fatality. Herschell states the law incorrectly in the marginal reference to the subject, though it stands right in the body of the paragraph.

In paragraph 745, Dr. Bird makes the erroneous statement that the middle glass, sometimes introduced into compound microscopes, to increase the field of view, *increases* also the magnifying power. In paragraph 852, the relations of alum and rock-salt covered with soot to the unequally refrangible rays of heat are interchanged. The crude notions which Dr. Bird has of the optical doctrine of interference are manifested in the last sentence of paragraph 865.

We have made a collection of more than fifty other errors in the book, of every degree of importance. We have only space to refer the reader to paragraph 59, where there are two numerical errors; to the formulæ for falling bodies given in paragraph 91; to the laws of the pendulum as they are stated in paragraphs 105 and 108; to the effect of temperature on sound as mentioned in paragraph 226; to the principle of vibrating cords as represented in paragraph 237, C.; and to the algebraical formulæ which express the position of the foci of concave mirrors for diverging and converging rays, as these formulæ run in paragraphs 573 and 574. For accidental errors, either of the author or the press, and for improper expressions, (the result of too great haste in the preparation of the book,) we may refer to paragraphs 37, 47, 79, 84, 89, and many others.

After all the praise which we have been willing to bestow upon Bird's Elements of Natural Philosophy, it is clear that

it is overrun by errors of all kinds and dimensions; errors which have sprung from an ignorance of mechanical laws and mathematical analysis, or which have originated in a careless literary execution. To these errors of thought and expression, we must add errors of the press, which are very numerous. Errors of this class are more excusable, and would readily be pardoned in this case, were it not that nearly all of them, and some more serious blunders, have been repeated in three editions of the book. As very considerable additions have been made to the work in successive editions, it will be understood, of course, that we do not mean to assert that the mistakes which occur in the new matter were also made in previous editions which did not contain this matter.

We need not insist upon the importance of every kind of accuracy (even that of the typography) to the usefulness of a text-book designed for elementary instruction. The pupil leans upon his text-book till he has reached an advanced stage of proficiency. In scientific works, wherever they relate to matters of fact, all who do not observe and experiment for themselves must rely upon the text-book. Our own intuitions cannot decide upon the truth or falsehood of an asserted fact. Sometimes a wide range of scientific knowledge may put a single individual right, by the power it gives him of confronting one asserted fact with others with which it is inconsistent. This can only happen in cases where something like a law has been discovered, and the application is not always easy even then. Some persons may think, that the liability of a text-book to errors exercises the mind of the student, forces him to reflect, to compare passage with passage, and fact with fact; and so cultivates independence of thought. With mature minds, this may sometimes be the effect. But whenever the learner's knowledge of a subject is imperfect, he can succeed in persuading himself that the book is right even where it is wrong, by some false view to which he has contrived to accommodate his ideas. Sooner or later, he finds that the book was wrong, and that he did wrong in yielding up his convictions so readily to it. The reaction is likely to make him afterwards too prompt to suspect his guide, and to turn off every new difficulty with this suspicion, and thus give up the exertion which is needed to understand the subject. If, therefore, a book contain scores of mistakes of

all kinds, the pupil is disheartened, his vanity is wounded when he discovers that what he professed to understand was self-contradictory and absurd, and he may be tempted to abandon the study of the subject altogether.

In 1848, an American edition of Bird's Elements of Natural Philosophy was published at Philadelphia, which is a faithful transcript of the revised and enlarged third London edition. As this reprint is more likely to be generally consulted in this country than the English editions of the work, it would have been extremely fortunate for our own pupils, if the errors in the original, which we have pointed out, had been corrected in the American republication. But this is not the case, so far as we have examined, except in a single instance, where the number of the paragraph, which is printed incorrectly in the original work, is set right in the home edition. In every other example, errors of the most serious and the most trivial character, errors of analysis, errors of general statement, errors of style, errors of the press, errors of ignorance, and errors of careless haste, all are scrupulously copied and reproduced and perpetuated, to the detriment of the American student, as they had already been repeated and transmitted in the successive London editions. As they have survived four editions and eleven years of scrutiny, or want of scrutiny, perhaps they will go on undisturbed to poison the minds of all those who come to the book for guidance and instruction. An intelligent proof-reader in a well-regulated printing-office, without any special scientific or literary acquirements, would have been a guaranty against some of these errors.

For example, in paragraph 713, we read "Another process is that of M. Fresnal [Fresnel] by allowing a ray of plane polarized light, A B, to suffer two reflections from the internal surfaces of a parallelopipedon of crown-glass, where [whose] acute angles, K L, are inclined at 54° 30′ and when [whose] obtuse ones M N are equal consequently to 126." A little farther on we have *heat* instead of *light*. All the errors, corrected by us in brackets, are faithfully retained in the various editions of the work. The same is true in other places, where we have *elliptic* instead of *ellipse*, *Bibot* for *Biot*, *cubic* for *cube*, 2500 instead of 250; and in many passages, where a letter or word has been accidentally

changed or omitted at first, and the error is preserved inviolate.

We cannot refrain from saying a word in praise of the substantial paper, the clear typography, and the distinct woodcuts of the English editions, as contrasted with the poor paper, blurred illustrations, and dirty type of the American reprint. We have some regard for the eyes as well as the intellects of young students. We fear much that the infirmity of vision, which has increased so alarmingly among young and old, is aggravated, if it is not occasioned, by poring over the dim and crowded pages of some of our recently published text-books.

Whoever is in need of an elementary treatise on general physical science, and does not find his want satisfied by Bird's Elements of Natural Philosophy, must take refuge in the recent translations of one or two foreign works on physics. A translation of that portion of Despretz's Physics which relates to the mutual action of voltaic currents, was published in the second edition of Farrar's Electricity and Magnetism. An excellent treatise on the Elements of Physics (*Lehrbuch der Physik*) was published at Leipsic, in 1844, by C. F. Peschel, Principal of the Royal Military College at Dresden. A translation of the work into English, with notes, by E. West, appeared at London in 1845–6, in three volumes. A republication of this translation, made in proper style and corrected in a few particulars, would be a valuable text-book in American colleges. The translation of a foreign work, especially a German work, has this advantage, for those who speak the English language, over one written originally in their native tongue; it contains facts and describes instruments with which they are less familiar, either in their own language, or in French. Those parts of Peschel's work which discuss the subject of light, and of undulations in general, are full of merit. The book addresses the reader in popular, rather than in mathematical language; and if, on this account, it were less serviceable to one who desired to exhaust all the analytical intricacies of these subjects than such works as those of Lamé or Moigno, it is more freely accessible to the majority of those who frequent our halls of education. We have not had an opportunity of comparing the translation of Peschel with the original, and

therefore we dismiss it for the present with the remark, that the work itself is unsurpassed by any general treatise on physics that can be found in any language.

In 1844, Johann Müller, Professor of Physics and Technology in the University of Freiburg, in Breisgau, published a treatise under the following title: "*Pouillet's Lehrbuch der Physik und Meteorologie, für Deutsche Verhältnisse frei bearbeitet.*" Pouillet's *Eléments de Physique* is well known and highly valued in this country, as well as in France. It has passed through five editions, but has never been directly translated into English. A translation into our own language of this standard work would be a valuable addition to the scientific equipment of those who cannot study it in the original. The aim of Müller, in translating Pouillet's work into German, was not unlike that of Dr. Bird in the preparation of his Elements. It was, as we learn from the preface to the first edition, to meet the wants of general readers and young students, rather than to teach men of science; to furnish a manual of the most useful portions of physics to such as are engaged in kindred branches of science or of the arts which are cognate to them, — as chemists, physicians, pharmaceutists, technologists, political economists, &c. To accomplish this purpose, it was sometimes necessary to depart from a bare translation of the original French, to modify the old, and add much that was new. It was a principal object to discard, whenever it was possible, all mathematical formulæ, and to illustrate and explain, when it would not answer to reject them; so that every thing in the book might be intelligible to such as possessed only the rudiments of mathematics. The portions of the work which treat of molecular action and of acoustics have been least altered from the original, and those which relate to the mechanical laws have suffered the greatest change. The French writers on physics only touch upon mechanics. To make his work fit for the purpose he had in view, Müller treats more at length of the parallelogram of forces, of the lever and balance, of the free fall of bodies, of the laws of the pendulum, of specific gravity, the aerometer, and the expansion of gases by heat. The steam-engine is illustrated, and the laws of magnetism are enriched by an elementary statement of the researches of Gauss, — researches

which are not noticed at all in the original work. The chapters which discuss galvanism Müller claims as almost entirely his own; particularly the part which relates to the chemical influence of the circuit. Important changes have been introduced into the chapters which treat of electrical induction; also into those which develop the laws of optics, especially physical optics, as diffraction, polarization, and double refraction, in which the reader will find little in common with Pouillet. "I have sought here," says Müller, "to unfold in the most elementary and intuitive manner the elements of the wave theory." In regard to that part of Pouillet's treatise which relates to meteorology, Müller speaks thus: "Pouillet's meteorology, in the opinion of all intelligent men, corresponds so little to the latest point of view of German science, that a complete change was necessary in it. Such a change, for which I have made use of the resources and particularly the lectures on meteorology of Kämtz,* is in many respects a very difficult task. I can only hope that my attempt may not have utterly failed."

This work of Müller met with so welcome a reception that a second edition was demanded immediately after the completion of the first. Inferring from this great success that the plan of the work, in spite of many faults of detail, appeased an urgent want in the community to which it was addressed, Müller proposes to adhere to it still more rigidly in the second edition. Universal intelligibleness, he says, is the point at which I aim. To this end, the arrangement of the whole work is so altered that the subjects follow each other in a natural order, and the injudicious separation of the laws of heat into two parts is avoided. The laws of sound and light follow the mechanical parts. But it is not in arrangement only that the second edition is an improvement upon the first. All over the work, additions as well as improvements are found, and a radical change is made in the portions given to acoustics. In consideration of all these alterations, begun in the first edition, and continued and multiplied in the second, so as to leave in the latter little which belongs to the French work, Müller felt himself justified in altering the title of the new edition so as to read, "*Lehrbuch der Physik und Me-*

* Erroneously spelt Kaemptz in No. 148 of this Review.

teorologie, von Dr. J. Müller, &c. Als zweite umgearbeitete und vermehrte Auflage der Bearbeitung von Pouillet's Lehrbuch der Physik." In 1847, the third and last edition of Müller's book was published. The most important discovery, in the opinion of the author, which had intervened between the publication of this and the previous edition, was Faraday's discovery of diamagnetism, and of the change in the plane of polarization which is effected by magnetic and voltaic currents in a ray of polarized light which is passing through a diamagnetic substance. This pregnant experiment of Faraday establishes, as Müller thinks, an important relation between light and electricity. In our opinion, the relation is not different in character from that which Brewster and Fresnel had long ago found to exist between light on the one hand and mechanical and calorific disturbance of the molecular arrangement on the other. In this last edition, the laws of heat have been enriched by the fruits of Regnault's labors, and the laws of light by the prismatic analysis of the colors of interference. In other respects, the third edition is the same as the second. For the benefit of those who had purchased the earlier editions, Müller has published his additions and improvements in two supplements, which are sold separately from the whole work.

The peculiarities to which we have adverted in Müller's book mark it as one exceedingly well adapted to general students. What they require is a sweeping view of the whole subject of physics, such as suits the demands made upon every man of liberal education, and can be compassed without extensive mathematical attainments. On this account, we are persuaded that a translation of Müller's work by any competent person, who had the heart to undertake it, would be at once installed as a text-book in our colleges, and would meet the approbation of teachers and professors of physical science generally. Müller has also published, under the title of "*Grundriss der Physik und Meteorologie*," two editions of a still more elementary work on physics than the one we have just noticed. This new work is mainly identical with the *Lehrbuch*, after the latter has been reduced to about half the number of pages and illustrations contained in its original form. Wherever the course of physical instruction is very limited as to time and completeness, this miniature copy of

Müller's Physics will be preferred to the larger work. This abridgment, in which the reader will recognize very little that belongs to Pouillet's treatise, (which was the stock on which these various publications were engrafted,) was translated and printed in English in 1847, under the title of "Principles of Physics and Meteorology." The translator, whose initials correspond with the name of one of the translators of Humboldt's Cosmos, speaks thus of his task: "Of the manner in which the translator has executed his task, it behooves him to say nothing; he has attempted nothing more than a plain and nearly literal version of the original." This translation was republished at Philadelphia in 1848, and we give the following extract from the publishers' preface.

> "In preparing it, the American publishers have availed themselves of the services of a competent editor, who has made various alterations and additions. . . . . . Articles have also been added on the electro-magnetic telegraph, electrotype, steam-engine, &c., with the necessary illustrations, while various errors of importance, which had escaped the London editor, have been corrected. The publishers hope that the care exercised in the revision of the work, and the accuracy of the text, which it has been their aim to secure, will be deemed of sufficient importance to enhance the value of a work which has already received deservedly high commendation."

We have had an opportunity of examining both editions of this translation, and have made a laborious comparison of the American edition with the original German. We selected the American edition for this purpose, as being the one in which our own teachers and students were most interested. We regret to say, as we must, after a close examination, that the translation is neither an intelligent nor a careful one, that it is often inelegant and awkward, that it contains some extraordinary words, and frequently perverts the sense of the original. There are numerous other mistakes, which are the fault either of the translator or the printer; if they are chargeable to the latter, the typographical accuracy of the book is of a low order. We have made a collection of one hundred and fifty mistakes, of every description and degree, in the American edition, and, with only two or three exceptions, they have all been copied from the English edition. The errors in the translation are such as no one, acquainted with the

subject of the book, could ever have made ; and the accidental errors, as we are willing to regard them, in the English edition of the translation, are mostly such as an American editor, with a little reflection and a very little science, might have detected and corrected. The American publishers assure the reader that various errors of importance, which had escaped the London editor, have been corrected. We can assure the reader that one hundred and fifty errors, none wholly unimportant, and many of considerable magnitude, have escaped the scrutiny of the competent American editor, and disfigure the reprint as they had already disfigured the London edition, of which the reprint is little better than a blind copy. We are aware that several wholesale additions and alterations have been made; but no thought has been exercised in the details of the work, and the attempt of the editor to reduce the centigrade thermometrical degrees, which were retained by the London editor, to Fahrenheit's scale, has been carried out so clumsily and imperfectly as to be quite untrustworthy.

We propose to give a few specimens of the various errors to which we have referred, as illustrative of the genus to which they belong. We will first notice some of the errors of translation; and in all our references we shall use the pages of the American edition. We must add that we have compared the translation, not with the first German edition from which it was made, but with the second German edition. It is possible that some of the errors to which we shall allude are chargeable on the original work, and have been corrected in the second edition. We do not believe, however, from the character of the errors, that the translator will be able frequently to offer this plea or defence.

On page 111, *Oberflache* is translated *upper surface,* though the word means *surface* simply, and the context shows that in this passage it was really the *under surface* which was spoken of by the author.

On page 176, *Die wir gleich näher betrachten werden* (which we shall consider presently) is rendered, *which we proceed to consider more attentively.* It is surprising the translator was not struck by the fact that the author, after so fair a promise, did *not* proceed to consider the subject.

On page 197, we read, "The laws of the passage of gases

through openings in thin walls, and through conducting pipes, are analagous to those bodies of liquid with which we have become acquainted;" *sind denjenigen ganz entsprechend, welche wir schon bei tropfbar flüssigen körpern kennen gelernt haben.*

On page 388, *kugel* is translated *body*, instead of *sphere*, although the whole point of the sentence depends on this word. On the next page, *dünner* is translated so as to refer to *density* instead of *bulk;* although this translation destroys the meaning of the sentence. Moreover, *dichter*, which means *more dense*, and is so rendered by the translator, occurs twice in the paragraph in which the mistake is made.

On page 411, we are thus directed: "and to effect this, it is only necessary to hold one pole in one hand, (*in der hand*, in the hand,) while we touch with the other *hand* (*mit der andern*, with the other pole) the plate or the ball of the electromotor."

On the bottom of page 528, we begin to read, "the temperature of the vessel falls, however, simultaneously, as all the heat which had been combined is given off at once by the energetic formation of steam." Then it is surprising that the temperature should fall, if so much heat is given off. The original is, *Gleichzeitig aber sinkt die Temperatur des Gefässes, weil er alle die Wärme liefern muss, welche auf einmal bei der heftigen Dampfbildung gebunden wird;* that is — "but at the same time the temperature of the vessel falls, because it must supply all the heat which is made latent at once in the energetic formation of the steam."

On page 600, we read, "they (the rain-drops) increase in size, however, as they fall, owing to the vapor of the strata of air becoming condensed, on which account they fall." *Sie werden aber während des Fallens grösser, weil sie wegenihrer geringeren Temperatur die Wasserdämpfe der Luftschichten verdichten, durch welche sie herabfallen.* "But they become larger as they descend, because, on account of their lower temperature, they condense the water-vapor of the strata of air through which they fall." In the next paragraph, *jederzeit* (at any time) is translated *every time*, so as to make nonsense.

On page 609, *namentlich, wenn die Tropfen in einer nur etwas bedeutenden Entfernung vom Auge sich befinden,* is

rendered, "especially when the drops occur at *only a slight*, (at a considerable,) distance from the eye." On page 238, *bei den Durtonarten*, (in the major key,) is rendered "*through the gamuts*;" and below, *bei den Molltonarten*, (in the minor key,) is translated, "*in the soft-toned gamuts*." On page 392, *die eine Belegung* is translated, "*the one coated surface*;" and not, as it should be, "one of the coated surfaces." On page 533, we read, "The cold water, which enters the condensing tube, flows forth from the other end heated." It should be, "The water which enters the lower end of the condensing tube cold, flows forth from the upper end heated." *Das Kühlwasser, welches am untern Ende des Kühlrohrs kalt zufliesst, fliesst am obern Ende des Kühlrohrs erwärmt wieder ab.*

On page 180, *wenn wir in diesen Werth von c′ den eben abgeleiteten Werth von g′ setzen*, (if we introduce into this value of c′ the value of g′ just obtained,) is translated, "if we add the value of g′ to this value of c′." On page 239, *Temperatur*, which the context shows must mean, in this case, *musical temperament*, is translated, *temperature*. On page 354, *Folgepunkte*, which in magnets means *consecutive points*, is translated *successive stoppages*. On page 398, *Blitzröhren*, which in electricity means *lightning tubes*, is translated *lightning conductors*. On page 556, *Ekliptic*, which means *ecliptic* in English, is translated *elliptic*. On the next page, *Gestirne*, which means *stars*, is translated *planets*. On page 570, and throughout, *isotheren*, which means *isotheral*, is confounded with *isothermische*, which occurs a few pages before, and is rendered by the same word, *isothermal;* that is, the lines of equal *summer* heat are confounded with the lines of equal temperature. On page 581, *indem* (because) is translated *although*; and on page 594, *oder* (or) is translated *otherwise*; and the sense is ruined in both cases.

Let us see now some of the more trivial errors, which, whether originally caused by the carelessness of the translator or the printer, are copied by the American editor. A competent editor would have detected and corrected them on the most hasty perusal. At the top of page 573, we read, "These differences are owing to the more easy absorption and radiation of heat, which becomes heated and again cooled more rapidly than the sea, which, *by the continent*, is every-

where of a uniform nature." The words in italics are out of place, and should follow the word *heat.*

On page 39, we have *by*, where we should have *and.* On page 55, *mit Worten* (in words) reads *inwards.* On page 61, we have *quantity* instead of *gravity.* On page 109, we have *minor* for *inner;* on page 132, we have *friction* for *piston;* on page 137, *close* for *strong;* on page 150, *on equal terms*, for *in equal times* (in gleichen Zeiten); on page 153, *m* for *n*; on page 170, *rebound* for *does not rebound;* on page 173, *check* for *clock;* on page 234, *end* and *middle* change places; on page 241, we have *sure note*, instead of *pure note;* on page 262, *focus* for *centre;* on page 268, *vertical* for *imaginary;* on page 430, *polatine* for *positive;* on page 481, *Mobile* for *Nobili*; on page 507, *pass* for *press* (drücken); on page 545, *transparent* for *nontransparent;* on page 578, *thermometer* for *barometer*, twice; on page 581, *land wind* for *sea wind;* on page 596, *they* for *it;* on page 601, *decreases* for *increases;* on page 607, *transitive state* for *transition state.* On pages 161, 189, 225, 236, 544, 588, &c., words are omitted so as to obscure the sense, though the omissions can be readily detected if the passages are read with attention.

We have alluded to the occasional want of elegance and literary exactness in the translation. This defect is of less importance in a scientific work than a misstatement of facts and laws; therefore we shall illustrate it with great brevity. On page 121, we read, "In order that two different columns of fluid should be equipoised, it is *necessary* that their height *must be* inversely as their densities." Again, on page 244, "Such a system forms a whole, which, if a point be made to vibrate, will be like a single solid body *divided* into separate vibrating parts, divided by nodes of oscillation." On page 96, *oben* is translated *superiorly.* We also encounter such unusual words as *doubtlessly* and *closure.* Perhaps the latter word could not be avoided without changing the form of the sentence.

The decimal system of weights and measures and the centigrade thermometer are used exclusively by Müller. We should rejoice to see the metrical system (with the exception of the centigrade thermometer, which is not a natural part of the system) introduced into English and American science,

that the metre might go round the earth in use, as it does by its multiplied extension. It is time that a delivery should come to all men from the uncertainty, complexity, and instability of *long measure* and *short measure*, of *Troy weight*, *avoirdupois weight*, and *apothecaries' weight;* of *dry measure*, *beer measure*, and *wine measure*. In the reign of Queen Elizabeth, the English standard of length was an old poker, which, being once broken, was joined together carelessly, and still continued in use. Certainly some improvement has taken place upon this state of things ; but the weights and measures used in Great Britain and this country, in simplicity, symmetry, and consistency, are not to be compared with those of the decimal system. The metre has but one value over the whole world ; the foot means a different thing in every different petty principality of Europe, and is almost as various as if each individual should use his own foot as the standard of length. We think that the English translator has acted wisely in retaining the metrical standards used by Müller, giving only a short table of the values of the principal ones in English measures, a table which the American editor has materially enlarged. We think, however, that it would have been better if the centigrade degrees had been reduced to Fahrenheit's scale, as the latter possesses advantages over all others, though itself confessedly imperfect. In one instance, the translator has forgot himself and reduced the temperature to Fahrenheit's scale.

"For a temperature of 68°, [20° in the original,] for instance, the maximum of the force of tension of steam is 17.3 millimetres, and the corresponding density of the steam, 0.00001718; in a vacuum of one cubic metre, at a temperature of at most 68° [20° in the original,] 17.18 grms. of water may be contained in the form of vapor."

In the first place, there is a grave error in the translation, which a thoughtful reader would have paused to correct. The latter part of it should be, "in a vacuum of one cubic metre, at a temperature of 68°, 17.18 grms. of water at most may be contained in the form of vapor." Our American editor allows this mistake to pass ; he also overlooks the fact that the temperature in this passage was expressed in Fahrenheit's scale, (a fact, which the table on page 504, enlarged somewhat by himself, would have taught him, if he had consulted it) ; and so, to make matters sure, he reduces the

Fahrenheit degrees again to Fahrenheit; makes another original blunder by writing, in the place where the temperature is last mentioned, 78° for 68°, and reducing it as such, when it should not have been reduced at all; so that the whole passage reads thus:

"For a temperature of 68° (154° F.) for instance, the maximum of the force of tension of steam is 17.3 millimetres, (.633 in.) and the corresponding density of the steam, 0.00001718; in a vacuum of one cubic metre (27.0.3 cubic feet,) therefore, at a temperature of at most 78° (172° F.) 17.18 grms. (264.93 grs.) of water may be contained in the form of vapor." pp. 591-2.

The explanation of the American editor's original blunder is not to his credit. On the same page of the English edition, in two other passages, 78° is written erroneously for 68°. The American editor copies both these mistakes, makes two other mistakes in reducing each number to Fahrenheit, and then volunteers an additional change of 78° for 68°, where it stands right in the English edition. By such a tissue of blunders, the confiding student is misled, and the time of even an accomplished scientific man is wasted in discovering and avoiding the error.

A paragraph on page 537 contains three mistranslations, which the American editor has copied, and to which he has added one error of omission and seven of commission. Some of the positive errors were occasioned by reducing the centigrade degrees to Fahrenheit's, and not making any account of the mistranslations. Others are the result of another sort of carelessness, — that is, of reducing part of the paragraph to Fahrenheit's scale, and not other parts numerically associated with the former.

"If we assume that a platinum ball weighing 200 grms. (3088 grs.) warmed to 212°, has been immersed in a mass of water of 105 grms. (1621 grs.) at 59°, and has raised its temperature, by its own cooling, to 68°, that is, has heated the water 9°, it is clear, that the 200 grms. (3088 grs.) of platinum must be cooled down *to* 176°, in order to heat 105 grms. (1621 grs.) of water 9°. The same amount of heat that has been yielded by the platinum ball would, therefore, also have sufficed to raise the temperature of 525 grms. (8108 grs.) of water (1.8°.) If the platinum ball had only weighed one grm. (15.444 grs.) the amount of heat given off by it, *at* a depression of temperature of 176°, would be able to warm only $\frac{525}{200}$, ($\frac{8108}{3088}$ grs.) or 2.625 grms.

(grs.) of water, (1.8°,) or 1 grm. (15.444 grs.) of water 2.625°. Hence, it follows, that the same amount of heat that raises the temperature of 1 grm. (15.444. grs.) of platinum 176°, can only raise an equal mass of water 2.625°; platinum thus requires only $\frac{2,625}{80}$, that is, 0.0328 times less heat that an equal *quantity* of water, to experience an equal variation of temperature; the specific heat of platinum is consequently, 0.0328."

This statement, so absurdly and variously inconsistent with itself, should be thus: —

"If we assume that a platinum ball weighing 200 grms. (3088 grs.) warmed to 212°, has been immersed in a mass of water of 105 grms. (1621 grs.) at 59°, and has raised its temperature, by its own cooling, to 68°, that is, has heated the water 9°, it is clear that the 200 grms. (3088 grs.) of platinum must be cooled down by (*um*) 144°, in order to heat 105 grms. (1621 grs.) of water 9°. The same amount of heat that has been yielded by the platinum ball would, therefore, also have sufficed to raise the temperature of 525 grms. (8108 grs.) of water 1.8°. If the platinum ball had only weighed 1 grm. (15.444 grs.) the amount of heat given off by it, by (*bei*) a depression of temperature of 144°, would be able to warm only $\frac{525}{200}$ ($\frac{8108}{3088}$) or 2.625 grms. (40.54 grs.) of water 1.8°, or 1 grm. (15.444 grs.) of water 4.725°. Hence it follows, that the same amount of heat that raises the temperature of 1 grm. (15.444. grs.) of platinum 144°, can only raise an equal mass of water 4.725°; platinum thus requires only $\frac{4725}{144}$, that is, 0.0328 times less heat than an equal mass (*Wassermasse*) of water, to experience an equal variation of temperature;" &c.

These are not the only dilemmas into which the American editor has fallen in his ambition to improve upon the English edition. On page 496, —10° of the centigrade scale is put down as —18° of Fahrenheit, instead of +14°. In the second paragraph, which treats of latent heat, (also on page 496,) the degrees are reduced to Fahrenheit; in paragraphs fourth, fifth, and sixth, they are not; and yet they are intimately related. The subject closes up with a mistranslation. "Pulverized Glauber's salts, over which muriatic acid has been poured, give a fall of temperature of (from) +50 to —1.4 F." On page 532 we read, —

"We have already stated, that, for the unit of heat, that quantity of heat is assumed which is requisite to raise the tempe rature of 1 lb. of water 1°; to raise the temperature of 5½ lbs. of water to the same amount, 5.5 are therefore necessary, and

550 such units of heat to raise the temperature of this mass 212°."

Here the American editor was in straits. If he did not reduce the degrees of the thermometer to Fahrenheit, there would be a want of sequence between this paragraph and the preceding; if he did, there was a glaring inconsistency between this paragraph and the statement on page 496, to which he refers in it. He concludes to reduce, reduces incorrectly, and forgets that he has reduced at all. The last portion of the passage, reduced to Fahrenheit, should stand thus: "to raise the temperature of $5\frac{1}{2}$ lbs. of water to the same amount, 5.5 are therefore necessary, and 990 such units of heat to raise the temperature of this mass 180°."

After this, we can hardly be surprised that Müller's remarks on the pressure and motions and clearness of the air in Europe, in which he makes use of the expressions, "in our districts," and "in our latitudes," should be allowed to stand unmodified, as if they were just as applicable to the eastern shores of this continent as to the western shores of Europe. And here again, page 580, the meaning of the author is weakened by a bad translation. "This is, however, only, as we have before remarked, an average rule; for the sky is often cloudy with a northeast wind, and clear with one coming from the southwest; the statement is in so far true as that the barometer stands high or low according to which of these two winds prevails, the remark in the latter case being nearly true on the average." *Sie ist jedoch in derselben Ausdehnung wahr wie die, dass bei Nordostwind das Barometer hoch, bei Südwestwind dagegen tief steht: dies ist auch nicht immer, sondern nur im Durchschnitte wahr.* "It is true to the same extent as this, that the barometer stands high in a northeast wind, and, on the contrary, low in a southwest wind; but this also is not always true, but only on the average."

The English edition of the translation of Müller's work appears comely in its white dress and clear typographical expression; the beautiful and abundant wood-cuts, (of which there are more than five hundred,) by which it is illustrated are an ornament to it. The American edition, also, is refreshing to the eye to behold in these days of dusky paper and small type. Both editions of the translation have closely imitated

the style of the German illustrations, which are very excellent, especially in the parts which refer to the wave theory of light. The white lines upon the dark ground, suggesting to the student his chalk and blackboard, are a gratifying novelty in the garniture of a text-book. The eye is also captivated by two colored plates, on the colors of diffraction and polarization, which are only surpassed by the exquisite plates on the same subjects in Pouillet's Physics. It is certainly to be regretted, that the two editions of the translation which we are considering, though so pleasant to the sight, should turn to bitterness when tasted. It is to be regretted, that the publishers at home and abroad could not afford to pay as liberally for the literary, scientific, and typographical accuracy of their publication, as for the outside show with which it should parade before the public. We have no doubt that the translator, badly as the work is done, fulfilled his contract with the publishers, by expending all the time and labor upon it for which he was paid. If the English publishers did not reward the author for his work, generosity would dictate that they should not injure his reputation by a false translation of his ideas. If the American publishers saved the expense of the translation, the translator might fairly claim, that, if his errors were not corrected, they should not, at least, be aggravated by the American editor; and the public might expect to enjoy the luxury of being mistaught without paying an exorbitant price for it.

A necessity is laid upon men, which will compel them to use both of the works at which we have taken exceptions, (Bird's Elements of Natural Philosophy, and the translation of Müller's Principles of Physics and Meteorology,) until better books are written, or good books are better translated. How low must be the standard of scientific scholarship in Great Britain and in this country, if those who use these text-books of science are satisfied, or, though not satisfied, if they are unable to dispense with them! How long shall it be true, that the best English works on general physics, as developed at the present day, are translations from foreign treatises; and that these translations are so inaccurate that they cannot with safety be put into the hands of the pupil? How long shall it be true, that books which profess to teach the exact sciences are overrun with blunders which would disfranchise any literary production?